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BOOK REVIEWS

Qu'est-ce que le raisonnement? Deuxième Partie. De l'intuition à la déduction. PAR EUGENIO RIGNANO. Scientia. XIV., 1913, pp. 129-156.

The author having in a previous article discussed the simpler forms of reasoning, now passes to a second aspect of its evolution, namely, intuition and deduction. The former term he defines as "any new assertion which arises spontaneously and unexpectedly, *i. e.*, which occurs without previous search or intentional observation and without being preceded by repeated trials of pre-established verification." It may be the discovery of an attribute, of an object, or of an analogy between phenomena which occur suddenly, with no change in external conditions, but with the awakening of an affective state which, accidentally coinciding with these conditions, makes them of interest for the first time. This is practically what happens in every act of perception. Among the numerous sensible qualities, we discover those which affect this or that affectivity, and the unforeseen discovery of a new attribute in a familiar object is only a complement of the previous perception of the object in consequence of a new affective point of view. Galileo, for example, discovered the law of the isochronism of the pendulum by an intuition due to his mental preoccupation of an affective nature relative to the measure of time. The same result might have been reached by an observer who set himself to observe how the duration of the oscillations gradually diminished in proportion to the amplitude. In such a case, an affective preoccupation of the same sort as in the former case would have been implied, but the result would have occurred with certainty and not by chance. The nature of the discovery however would not have differed from that made by intuition.

Axioms and postulates, the empirical character of which is no longer disputed, are discovered by intuition aroused always by an interest, *i. e.*, by an affective state. As an example of the discovery of an axiom by intuition in animals the following case is quoted from Romanes. "A dog following the trail of his master along a street came to a point from which three streets led in divergent directions. Sniffing along two of the streets and finding the trail in neither of them he immediately ran down the third street without stopping to sniff." Here the desire of finding his master led him to the discovery of the axiom that if there are only three alternatives and two are excluded the third must be correct.

The first intuition of all the postulates of transition, among them the postulate that through a given point only one parallel can be drawn, is probably due to the discovery that the passage from one class of equivalent phenomena to another class of phenomena equally equivalent but opposed to the other from the affective point of view, is by way of the unique phenomenon of transition, which belongs to neither class.

From intuition as a mere statement of some fact or attribute which is immediately perceived we pass by degrees to intuition as

discovery which comes after a mental combination of experiences, often very simple, which are merely thought and this combination occurs suddenly and spontaneously under the impulse of a unique affective activity without control or correction by a state of corresponding attention, *i. e.*, there is present no secondary affective state which exercises an inhibitive control. It is probably to this kind of intuition, as has been shown in Part I of this discussion, that most of the thought experiences of animals belong.

But for another combination of mental experiences, otherwise completely analogous to the preceding, a certain amount of reflection is necessary. This may be due either to the fact that at first no mental combination of any kind presents itself, or it may be that the first combinations show themselves unsuitable for attaining the end sought. But the sole difference between this form of reasoning and intuition consists in the fact that, in the one case, the correct combination is attained only by repeated trials of which several must be rejected before one is chosen, while in the other, the "happy idea" accidentally presents itself first and immediately becomes the one chosen. But it is precisely by means of separate trials that reflect-reasoning excludes in great measure the chance attainment of the result which takes place in intuition.

Intuition also leads us to the discovery of the general validity of a particular demonstration, as in geometrical demonstrations. This immediate vision consists in the fact of seeing mentally and instantaneously that when the same series of experiences which make up the demonstration are repeated upon imaginary figures, of which certain aspects are varied, the result always remains the same. Intuition in this case then resolves itself into the mental repetition of as many of the series of experiences as there are different forms of the figure mentally presented, and each of these series is similar to the first one carried out upon the actual figure drawn on the paper or blackboard. But generalization does not always occur through intuition. Though not at all changed in its nature it frequently exacts a certain amount of reflection which sooner or later succeeds in selecting the right combination, when intuition, unless favored by chance, might fail.

Sometimes intuition consists in the finding of analogies between phenomena which have previously been considered as totally different when viewed from the point of view of perception, but which nevertheless have some common attribute and are therefore equivalent as regards the obtaining of a particular result. The designation of this particular attribute, necessary and sufficient for such an equivalence, constitutes a scientific law. This extension of all that is known of given phenomena to other unknown phenomena is the foundation of induction and it is also this, as will be shown later, which permits the application of deduction in science. It differs from the generalization of a particular demonstration in that the result to be obtained is not already fixed in advance. As a result of this difference, intuition, which here is the insight of genius, cannot be entirely replaced by reflection. The principle of continuity, *i. e.*, the tendency to extend certain properties of a phenomenon which have been verified only under given circumstances, is precisely the same principle which the geometrician follows when he imagines the triangle under his eyes varied in every possible way. But all new analogies cannot be discovered by the principle of continuity, and it is just here that the intuition of the man of genius is of

supreme importance. There is thus an absolute necessity in science of continual alternation of intuition and reflection, the former to avoid sterility, the latter to control and test the validity of each new discovery.

More complicated forms of reasoning which are less susceptible of attainment by intuition and which most frequently require a certain amount of reflection are the principle of sufficient reason, demonstration by *reductio ad absurdum*, and the syllogism. As an example of the first two the author gives the mental process by which Stevin arrived at the formulation of the laws of equilibrium along an inclined plane. He imagined an endless chain placed over a triangular prism with two faces oblique and the third horizontal. The free part of the chain being in equilibrium could have no effect either to cause or hinder motion in the parts resting upon the inclined planes. This statement is in accord with Liebling's law of sufficient reason and depends upon the fact that the discovery that symmetry by itself implies the possibility of carrying out mentally two identical experiments upon the object or phenomenon and obtaining from these two identical experiments an identical result. This may be accomplished either by means of a simple change made between the symmetrical elements or by a change in the attitudes of the observer. Finally there is a mental verification of the result. Thus far the series of operations is not so complex but that they might be reached by simple intuition, but in the mental process followed by Stevin is found also an application of *reductio ad absurdum*; for the next step in the reasoning process is that apart from friction, motion, once initiated into such a chain, would be perpetual, since change in the equilibrium would be impossible. This is the regular procedure in *reductio ad absurdum*, the non-possibility of a fact not being easily established. An impossibility easier to recognize is established, which a mental combination more or less complex shows to be the inevitable consequence of the first. It depends then upon the principle of contradiction, *i. e.*, upon the reciprocal inhibition of antagonistic images, a mental process which the author considers analogous to retinal rivalry. The affective state, the particular *malaise* which is characteristic of a logical contradiction is the same as in retinal rivalry. In both cases the disagreeable conflict provokes the corresponding desire of a reconciliation and ends by the elimination of one of the contradictory images. This may occur either because one is the product of the imagination or the antagonistic images may prove by reference to material facts to be two distinct objects. For instance, if one large and one small ball are attached to the arms of a balance and the latter, contrary to expectations based on experience, depresses the arm to which it is attached, a contradiction arises, which however disappears when it is found that the larger ball is hollow and therefore not equivalent to the mental image which was contradictory. It is further necessary that two contradictory conceptions in order to be mentally exclusive must be active at the same time, otherwise the contradiction is not observed, in the case of mental rivalry does not, in fact, exist. This explains the fact that individuals may often accept two contradictory propositions. Reasoning by exclusion is only a form of the principle of elimination of contradictory ideas.

The syllogism in the classic form consists in mentally separating, under the influence of an affective impulsion, the attribute which is necessary and sufficient to render several objects equivalent by

agreement with the tendency. It is mentally directed perception, *i. e.*, "a complement of perception in a determined direction, obtained by putting the observer or thinker at that point of view in regard to the end which is set forth by a general proposition." Or it may be a mental perception taking place at different times, so that interest is transfused from one attribute to another, and its importance lies in precisely this transfer of interest. It also permits a saving of time as regards induction and by the generalization contained in the major premise can lead to the discovery of new truths, that is, may be really productive.

The last section of the present article deals with causal explanation and deduction. The mind seeks inevitably to discover the how and why of every phenomenon and by examination of the process we find it to consist in a chain of experiences simply thought, which, by means of phenomena already known, allows us to arrive at the phenomenon to be explained. It is the necessity of inferring all phenomena, even those of the most complicated nature, from a small number of elementary phenomena which are known to us which constitutes what we call the necessity of a causal explanation, and it is from this necessity that the tendency of science to become more and more deductive is derived, but this tendency is quite a different thing from the possibility of its so becoming. It would be quite impossible to accomplish the vast number of combinations required by mental representation only, because it would be necessary to know the result of each of these separately. But if on the contrary, by means of intuition and the corresponding more or less hypothetical generalizations, those combinations which are equivalent as shown by agreement with a given result which has been experimentally verified, can be discovered, then the result can be applied to other combinations which are simply thought. Every extension of the deductive method implies a new corresponding induction and by this means the previously unknown results of a whole category of experimental combinations become known because assimilated with other categories of experimental combinations whose validity has been established. It is thus that we arrive at the discovery of concepts, laws and formulas which express new inductive generalizations. This generalized or schematized order permits the representation of whole groups instead of individual cases and thus by reason of the greater simplicity, permits a more extended series of mental processes. Thus general and abstract concepts contribute largely to facilitate the more extensive use of the deductive method, and thus the formation of concepts and the application of the deductive method proceed *pari passu*. It is evident that so complicated a series of mental acts could never be carried out by intuition alone but that intense and prolonged reflection, in which the primary affective activity, held in check by the secondary affective activity, is necessary in order to follow out and test all the mental combinations, to reject the unsuitable and to combine the experiences successively thought into a unity. But thought experiences alone would also be insufficient to arrive at conclusions unless tested by comparison with material facts and this is facilitated by means of a schematic representation of graphic symbols.

The more complex forms of reasoning in the exact sciences the author leaves for discussion in a later contribution.

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